STEM and Digital Technologies in Play Based Environments: A New Approach

In 2018 and 2019 the Early Years STEM Australia (ELSA) program was trialled in over 100 centres Australia wide. One of the mandated components of the program was the creation of four apps for children that would inspire curiosity and engagement in STEM concepts in preschool children. This symposium will outline our novel approach regarding the use of digital technologies (DT) with young children. It will initially look at research regarding the use of DT. The second paper will discuss STEM Practices and the Experience, Represent and Apply (ERA) heuristic that embed STEM and DT whilst remaining true to the core tenets of the Early Years Learning Framework. The final paper reports on engagement data collected in the trial that supports our novel approach to STEM in the early years.

Chair/Discussant: Doug Clements

Paper 1: Kevin Larkin & Tom Lowrie *The Role and Nature of Digital Technology use in Preschool STEM*

In this paper we critique existing research on the role and nature of digital technology use in Preschools. The majority of the literature points to overwhelmingly positive outcomes for young children when digital technology is thoughtfully used in play based learning contexts. However, despite the wealth of evidence that the use of tablets can be beneficial to preschool students, early childhood teachers often report being uncomfortable in teaching STEM. We suggest that, if accompanied by suitable professional development, tablets are an important addition to early childhood contexts.

Paper 2: Tom Lowrie & Tracy Logan *The Early Learning STEM Australia (ELSA): The Policy and Practice(s) of Engagement in the Early Years*

The Early Learning STEM Australia (ELSA) pilot was a year-long investigation involving 300 educators and 4 500 four-year old children in one hundred learning centres across Australia. This paper reports on a pedagogical and design framework that was constructed to promote children's STEM engagement across digital and non-digital learning environments. This paper describes this process in terms of a heuristic; since the educators in the study became part of the design team as they modified and adapted the activities developed by our team. The heuristic helped the educators modify and adapt the learning experiences to accommodate the diverse cultural and social needs of the students.

Paper 3: Tracy Logan & Kevin Larkin *ELPSA The ERA heuristic in action: Observations from the ELSA pilot.*

The Experience, Represent, Apply (ERA) heuristic is an innovation of the Early Learning STEM Australia (ELSA) project. It provided educators with an approach that embeds digital technologies in play-based learning in such a way that the focus of the learning remains on the child and not on the device. This paper reports on the experiences of early years educators and indicates that the ERA heuristic was instrumental in helping educators to integrate digital technologies in their everyday activities to promote engagement with STEM.

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Early Learning STEM Australia (ELSA): The Policy and Practice(s) of Engagement in the Early Years

Tom Lowrie
University of Canberra
<Thomas.lowrie@canberra.edu.au>

Tracy Logan
University of Canberra
<tracy.logan@canberra.edu.au>

The Early Learning STEM Australia (ELSA) pilot was a year-long investigation involving 300 educators and 4 500 four-year old children in one hundred learning centres across Australia. This paper reports on a pedagogical and design framework that was constructed to promote children's STEM engagement across digital and non-digital learning environments. This paper describes this process in terms of a heuristic; since the educators in the study became part of the design team as they modified and adapted the activities developed by our team. The heuristic helped the educators modify and adapt the learning experiences to accommodate the diverse cultural and social needs of the students.

The challenges of scaling and sustaining large-scale Government initiatives are profound—since most projects whither once funding ceases (Lowrie, Downes & Leonard, 2017). The ELSA pilot encountered two compelling constructs that heightened scalability and sustainability challenges in particular, namely: (1) science, technology, engineering and mathematics (STEM) needed to be defined in ways that promoted play-based engagement and enacted with such authenticity as to ensure highly diverse communities would remain engaged; and (2) learning opportunities could not rely of digital resources despite the fact the program required the development (only) of six learning apps that could be accessed through tablets.

With respect to defining STEM, our thinking was to not only improve educational practice but also provide a shift in educational purpose. Nevertheless, as English (2017) maintained, there are diverse ideas and opinions on what STEM should be and look like. Elsewhere we provide a justification for why STEM should not be limited to the four discipline areas that form the acronym (Lowrie, Leonard & Fitzgerald, 2018). As such, we see learning opportunities that focus on discipline integration, "real world" thinking and design thinking as both limiting and problematic. Rather, we focus on the *practices* (those ideas, methods and values) that manifest as STEM engagement— whether through engineering, technology, architecture or even surfboard design.

In relation to the development of digital resources, we understood the necessity of limiting children's screen time and to avoid an over reliance on the use of the digital resources. Moreover, alignment of STEM engagement to the principles and foundations of the Early Years Learning Framework (EYLF, Australian Government, 2009) was essential—consequently, digital engagement needed to be play-based and not merely associated with isolated game play or practise. To this point, the learning apps needed to be both part of an overall learning program and abreast of the spontaneous leaning environments that naturally occur in these preschool settings.

The capacity for educators to operate within a STEM Practices framework (see Lowrie et al., 2018, for details of the framework) was ambitious, however we felt that such an approach would be more productive than the hit-or-miss approach that could have eventuated in trying to find "authentic contexts" relevant or engaging to the students. After all, the hundred learning centres were distributed Australia wide across a diverse range of early learning contexts. These Practice *ideas* (e.g., problem finding, exploring and challenging), *methods* (e.g., using tools to produce artefacts, encoding and decoding information), and *values* (e.g., curiosity, creativity) needed to be promoted within a

connected set of play-based and intentional-teaching experiences in both on-app and off-app engagement.

A New Pedagogical Heuristic: Experience, Represent, Apply

The STEM Practice Framework introduced new content knowledge for the educators. It was also the case that most of the educators had not considered the role and nature of STEM engagement within the EYLF. This was unsurprising given the fact that the EYLF focused on literacy and numeracy understandings—the advent of STEM in the early years being a more recent educational phenomenon.

Although most of the teachers and educators we work with understood what STEM practices are about after the delivery of workshops across Australia, the implementation of the practices within a play-based learning environment remained challenging. To operationalise the links between the STEM framework we developed the “experience, represent, apply” (ERA) heuristic, provided scope for the sequencing of play-based activities and placement of digital experiences. The heuristic was derived from a school-based pedagogical model proposed by Lowrie and Patahuddin (2015), which described a way of designing learning opportunities through a process that mirrored typical concept development. The ERA heuristic was developed to assist educators to focus on engaging students in the use of STEM practices through the enactment of practices they can perceive to be authentic.

The ERA heuristic encouraged designers (our team) and educators to create learning activities that use or enact forms of STEM practices in the context of realistic real-world situations. The three stages of the design are cyclic in nature, with each phase developing children’s understandings within a framework that includes digital experiences within the learning design.

Experience. Children’s lived experiences are used as the foundation for concept development through social engagement and language. Children participate in a range of play-based, off-app experiences that provide opportunities for them to use language in ways that connect personal experiences with new understandings. The experience phase encourages the use of concrete artefacts and hands-on engagement.

Represent. Children engage with activities on the apps with affordances that represent STEM concepts in different ways. These representations include creating images, interpreting pictures, visualising and using symbols. Children have opportunities to create their own representations to use within the apps via the microphone and camera tools. Importantly, the digital affordances provide opportunities that are not able to be replicated effectively without digital tools. To this point, we maintained that activities that could be developed easily off app should not be replicated digitally.

Apply. Children build on their learning from the on-app activities through a range of off-app activities, guided by their educators and their families. Engagement with the visual and symbolic representations on the app also promoted new child-centred play-based experiences.

By way of example, in the *experience* phase children might copy a pattern from a story book stimulus read by the educator that describes patterns in nature. They might then collect some objects (e.g., Lego blocks or leaves) and create a pattern which they describe to another child. They *represent* such patterns (eg., an A-A-B pattern) on the tablet by taking photos of objects, which are captured in the app. The machine leaning within the app provides opportunities for scaffolded development of pattern sequences. In the *apply* phase, children create patterns that are drawn from their own story.

Active engagement with the app is restricted to the *represent* component of the learning design. The “experience’ activities are intended to establish understanding, as well as

encourage play-based curiosity to use the apps. The “apply” component of STEM Practices are similarly important, since the children are likely to disengage with the digital resources at any time, of their own choosing.

Complementary Methodologies: Iterative Pedagogies and Agile Digital Approaches in Practice

The STEM Practices Framework and the ERA heuristic have now been used extensively in both app design and piloting during the first year of the nation-wide ELSA project. The design phase for the ELSA program included our team (as pedagogical and content experts) and digital game developers and coders. The iterative methodology employed by the pedagogical team and the agile approach of the digital team provided opportunities for numerous mini-trials in learning centres as activities within the three elements of the heuristic were developed. As off-app and on-app activities moved from Alpha to Gold implementation, a second iteration of the design process occurred—with educators from the pilot sites being engaged as co-designers of the *experience* and *apply* activities that “bookended” the *represent* activities that were contained within the apps. In this sense, professional learning was ongoing, with educators challenged to modify and adapt “E” and “A” elements of the heuristic to produce learning activities that both (1) satisfied the tenants of the STEM Practices framework and (2) were abreast of the contextual and cultural nuances of their respective centres.

An analysis of the products of these educator “second waves” of iteration highlighted the functionality of the model since it afforded sufficient conceptual and pedagogic structure for educators to design complex and effective learning activities despite the content demands of understanding STEM concepts. To this point, the heuristic has provided us with an alternative to teaching content first—an approach that would simply not work at scale. Instead, the project has progressed through design discussions around the two parts of the model. The second ELSA app, for example, is associated with the spatial concepts of location and arrangement. Spatial concepts have a strong association with STEM engagement (Uttal, et. al., 2013) and can be developed rapidly within well-designed intervention programs (Lowrie, Logan, Harris & Hegarty, 2018). The ERA heuristic has provided a vehicle for educators to understand how to discuss the concepts associated with location and arrangement with educators as agents. These practices include the positional language, orientation and perspective taking.

One of the *experience* activities we designed for the development of location and arrangement understandings involved immersion with a book stimulus (see Figure 1a) written by members of our team (Simoncini, Logan & Kawka, 2018). The book promoted spatial language with a STEM Practice lens that involved children developing ideas (designing and building), methods (decoding and encoding information) and values (creativity, teamwork) through the lens of a STEM Practitioner (in this case, an architect). The *represent* activities included on-app experiences requiring children to solve perspective taking challenges (see Figure 1b). One educator was able to use the STEM Practices Framework and ERA heuristic to generate an authentic and contextually-rich application activity that captured the children’s engagement with these STEM understandings. The educator’s *apply* phase included the design and construction of a story book that featured all the spatial language and representations they had encountered throughout the term. Noteworthy, the story book had a strong STEM Practices theme associated with the challenges of understanding where a possum was hiding within the confines of the learning centre (see Figure 1c).

a b c

Figure 1. A Book Stimulus (a), App Activity (b) and Student Generated Book (c) Representing the Heuristic Nature of the ERA Process

Conclusions

The ERA heuristic provided educators with a sense of agency as they developed their understanding of STEM. Many of the educators were able to adapt and modify the experience and application activities we had developed in order to heighten authenticity and contextual appropriateness. At the same time, the heuristic was critical to the implementation success of the program since it provided the pedagogical team and the digital team with an approach to align the iterative nature of the pedagogic design to the agile digital development required for app production.

References

Australian Government Department of Education, Employment and Workplace Relations (2009). *Belonging, Being and Becoming: The Early Years Learning Framework for Australia.* Canberra: Commonwealth of Australia.

English, L. (2017). Advancing elementary and middle school STEM education. *International Journal of Science and Mathematics Education, 15*, 5-24.

Lowrie, T., Leonard, S., & Fitzgerald, R. (2018). STEM Practices: A translational framework for large-scale STEM education design. *Educational Design Research*, *2*(1). https://doi.org/10.15460/eder.2.1.1243

Lowrie, T., Logan, T., Harris, D., & Hegarty, M. (2018). The impact of an intervention program on students' spatial reasoning: Student engagement through mathematics-enhanced learning activities. *Cognitive Research: Principles and Implications, 3,*(1), 50-59.

Lowrie, T., Downes, N., & Leonard, S. (2017*). STEM education for all young Australians: A Bright Spots Learning Hub Foundation Paper, for SVA, in partnership with Samsung.* University of Canberra STEM Education Research Centre.

Lowrie, T., & Patahuddin, S. M. (2015). ELPSA as a lesson design framework. *Journal of Mathematics Education, 6*(2), 1-15.

Simoncini, K., Logan, T., & Kawka, M. (2018). *Map makers.* Canberra: Commonwealth Department of Education and Training.

Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: A meta-analysis of training studies. *Psychological Bulletin, 139*(2), 352-402.